

- P. F. Fox, ed., *Developments in Dairy Chemistry—3. Lactose and Minor Constituents*, Applied Science Publishers, New York, 1985.
- C. W. Hall, A. W. Farrall, and A. L. Rippen, *Encyclopedia of Food Engineering*, AVI Publishing Co., Westport, Conn., 1971.
- C. W. Hall and T. I. Hedrick, *Drying of Milk and Milk Products*, 2nd ed., AVI Publishing Co., Westport, Conn., 1971.
- W. J. Harper and C. W. Hall, eds., *Dairy Technology and Engineering*, AVI Publishing Co., Westport, Conn., 1976.
- J. L. Henderson, *The Fluid Milk Industry*, 3rd ed., AVI Publishing Co., Westport, Conn., 1971.
- H. G. Kessler, *Food Engineering and Dairy Technology*, Verlag A. Kessler, Freising, West Germany, 1981.
- F. V. Kosikowski, *Cheese and Fermented Milk Foods*, 2nd ed., F. V. Kosikowski and Associates, Brooktondale, N.Y., 1988.
- W. S. A. Kyle and B. R. Rich, *Principles of Milk Powder Production*, Victorian College of Agriculture and Horticulture, Victoria, Australia, 1986.
- United States Department of Agriculture, *Composition of Foods—Dairy and Egg Products*, USDA Agricultural Handbook No. 8-1, Government Printing Office, Washington, D.C., 1976.
- P. Walstra and R. Jenness, *Dairy Chemistry and Physics*, John Wiley & Sons, New York, 1984.

JOHN G. PARSONS
ROBERT J. BAER
VIKRAM V. MISTRY
South Dakota State University
Brookings, South Dakota

MILK, IMITATION

HISTORICAL BACKGROUND

Products resembling traditional dairy foods were strictly regulated in the United States in terms of sanitation, composition, labeling, and marketing by the Filled Milk Act of 1923 and the Filled Cheese Act of 1896 (1). The Filled Milk Act prohibited the shipment of filled milks and creams, which were defined as products made by combining milk solids with fats or oils other than milk fat. The Filled Cheese Act taxed the producers and distributors of filled cheese and the filled cheese itself to provide a means of identification of cheeses made to resemble natural cheeses.

Two developments in the 1970s directly affected the fabrication and sale of imitation and substitute milk products. On November 9, 1972, the Filled Milk Act was declared unconstitutional; as a result, the U.S. Food and Drug Administration announced that they would no longer enforce it (2). Even though filled milks could now be freely shipped in interstate commerce, the altered federal policy did not forbid the individual states from regulating filled milk sales within their borders. Marketing of fresh fluid filled milk and evaporated filled milk is still illegal in many states. The repeal of the Filled Cheese Act by Congress in 1974 further encouraged the development and marketing of substitute and imitation dairy products.

Why Imitations?

There are two reasons for the increased market share of imitation products: price and health aspects (3). From the pricing standpoint, vegetable fats are considerably less expensive than milk fat. Consequently, it is attractive to industry to replace the milk fat component in such high-fat dairy products as butter and cheese, whereas in the case of fluid or evaporated milk, milk fat replacement is much less economically feasible.

Rising concern about the fat and cholesterol content of the diet is another factor promoting selection of a imitation or substitute dairy food by the consumer. The substitution of unsaturated fats for some saturated fat in the diet is recommended to reduce the incidence of cardiovascular disease; filled dairy products may contain much higher levels of unsaturated fatty acids than traditional products with milk fat. Lactose intolerance is another factor where the consumption of imitation or substitute fluid milk may be beneficial. However, lactose-modified fluid milk products are available and can be consumed by lactose-tolerant individuals without difficulty (4). The International Dairy Federation has published consumption statistics on imitation products such as imitation cheese; unfortunately, no information was reported for the consumption of liquid or fermented milk substitutes (5).

DEFINITIONS

Imitation foods are regulated by the Federal Food, Drug and Cosmetic Act and the Fair Labelling and Packaging Act (6). The FDA established regulations in 1973 (7) to differentiate between imitation and substitute foods. According to the regulation, an imitation food is a product that resembles and substitutes for a traditional food but is nutritionally inferior. However, if the substitute food is nutritionally equivalent, by the FDA's definition, then that food does not have to be labelled imitation (8). Nutritional inferiority, as defined by the FDA includes any reduction in the content of an essential nutrient that is measurably present but does not include a reduction in calories or fat content. The U.S. Recommended Daily Allowance (RDA) is the guideline used by the FDA in developing the nutrient profile of a food to determine nutritional equivalence (6); 2% or more of the U.S. RDA of an essential nutrient present in one serving is defined as a measurable amount of that nutrient.

INGREDIENTS, COMPOSITION, AND PROCESSING TECHNOLOGY

Imitation or substitute fluid milks generally contain about 1–5% protein, 3–4% vegetable fat, 6–10% carbohydrate and various stabilizers and emulsifiers (9,10). They are frequently fortified with added vitamins and minerals.

Milk Analogues with Animal Proteins

The incorporation of casein (mostly in the form of sodium caseinate) into substitute and imitation milks, which are based on vegetable fats, and a carbohydrate, such as corn syrup solids, originated in the United States (9,10). Ca-

MILK, IMITATION

sein is used in the formulation of such beverages for nutritional purposes, but it also provides emulsifying capacity and stability. A typical formulation may contain 3.0% fat, 1.5% proteinate, 7.5% corn syrup solids, 0.5% emulsifier, 0.44–0.64% stabilizers, and 86.96% water (11).

Because the protein content of these products is frequently lower than that of fluid milk and the vitamin and mineral contents are not always equivalent, there is concern about the nutritional quality, so they are not usually recommended for infant feeding. The low protein content can also represent problems encountered by the manufacturer in making a beverage with acceptable taste quality and consistency (10). Conventional dairy plant equipment is used to process these products. The dry ingredients are preblended and mixed with water until dispersion is complete; the mixture is pasteurized, homogenized double stage at 175.8/35.2 kg/cm², cooled as rapidly as possible to 4.4°C, packaged, and stored under refrigeration (11).

Cheese whey or whey protein concentrate can be used for the formulation of high-protein milk-based beverages and nutritious soft drinks, provided they are defatted and have bland flavor and a low ash content (12). In one example, an isotonic beverage was prepared by mixing 3.0% whey protein concentrate with 4.9% sucrose and orange flavorings. After adjusting the pH to 3.5 with phosphoric acid, the beverage was in-bottle pasteurized at 75°C for 20 min (13).

Filled milks are made by substituting vegetable oils for milk fat. The oil is homogenized into fresh skim milk or recombined by homogenization with reconstituted nonfat dry milk. After pasteurization, the milk is bottled or processed into other products such as evaporated milk or cheese with only slight modifications to normal milk processing procedures (14). Vegetable fats used for this purpose are hydrogenated coconut oil or soybean or cottonseed oils (10). With the development of commercial sources, canola oil will assume increasing importance because of its desirable fatty acid profile. Coconut oil, which, until recently, has been the primary, if not the only fat used in manufacture of imitation and substitute milk products is a more saturated fat than milk fat and contains no linoleic acid, an essential fatty acid (1). Health professionals are recommending that it no longer be used in the manufacture of imitation and substitute milk products.

Milk Analogues with Vegetable proteins

The soybean, a staple food in many parts of the world, is the most important protein raw material for the manufacture of imitation milks with vegetable protein. The traditional Asian preparation of soy milk is a cold-water extract of water-soaked, ground soybeans. Whole beans are soaked overnight, ground wet, mixed with water, filtered, and the extract boiled to inactivate the trypsin inhibitor that reduces the nutritive value of the protein from the raw bean (15). Consumer acceptance of soy milk made by the traditional process has been limited in non-Oriental countries because of a characteristic beany or painty flavor. This off-flavor is the result of lipoxigenase enzyme activity; because the enzyme is heat labile, heat treat-

ment at an early processing stage greatly reduces off-flavor development. A popular soy milk prepared from full-fat soy flour is Vitasoy, marketed in Hong Kong as a soft drink. It contains water, soybean solids, malt, sugar, rapeseed (canola) oil, sodium bicarbonate, and salt. A 243-mL serving provides 110 calories, 4 g protein, 18 g carbohydrate, and 3 g fat (15).

Aseptically packaged soy-based milks are produced commercially in at least 12 countries, mostly in the Far East (16). For example, shelf-stable ultrahigh-temperature processed soy milk is manufactured commercially in Japan by a novel process where dehulled whole beans are steam injected in a tubular screw conveyor to inactivate lipoxigenase. The heated beans are ground with water, hammer milled to 100 mesh, centrifuged, and the supernatant standardized to 12% total solids (3.2% fat), including added sweetener and flavorings. The soy milk is then sterilized at 140°C for 1 min to inactivate trypsin inhibitor, deodorized by flash cooling in a vacuum pan, homogenized single stage at 180 kg/cm², chilled and aseptically packaged (15).

A nutritious beverage powder mix formulated from 41.3% sweet cheese whey solids, 36.5% full-fat soy flour, 12.2% soybean oil, and 9.0% corn syrup solids is especially designed to provide all the nutrients of whole milk when reconstituted with water to 15% total solids. The fluid blend is homogenized double stage at greater than 141/35.2 kg/cm², pasteurized at 70.4°C for 25 s, condensed under vacuum and spray dried. One per cent of a vitamin—mineral premix is dryblended into the powder to increase the nutritive value. A typical powder contains 20% protein, 20% fat, 2.7% moisture, 6.1% ash, 1.2% fiber, and 50.0% carbohydrate (primarily lactose from the sweet whey). The product is readily produced commercially with conventional milk plant equipment.

The manufacture of "toned" milk (Miltone) from groundnut (peanut) flour has been carried out in India for many years. Miltone is a milk of animal origin (cow or buffalo), extended with vegetable protein. It is prepared by extracting groundnut flour with dilute alkali and adjusting the extract to the isoelectric point to precipitate the protein. The protein isolate is slurried to pH 6.8 with water, buffer salts, and alkali; carbohydrate (usually sucrose), fat (a mixture of hydrogenated and refined vegetable oils), vitamins, and minerals are added. The mixture is blended with fresh bovine milk, sterilized, homogenized, and bottled. The toned milk contains 3.5% protein, between 4 and 8% carbohydrate, at least 2% fat and added vitamins and minerals (15). It is important that groundnut flour used for this purpose must be free of aflatoxin contamination.

Nutrient Analysis

An exceptionally detailed nutrient analysis of imitation low-fat milk powders intended for reconstitution into beverages has been reported compared to nonfat dry milk (1). Although the number of samples analyzed was limited, considerable compositional variability was observed in the imitation products. They contained significantly less protein and calcium than did nonfat dry milk; they were

also lower in phosphorous, magnesium, zinc, thiamin and niacin equivalents than nonfat dry milk.

The ingredients used in the manufacture of substitute and imitation milks are variable and may alter the nutrient composition of these products. Our knowledge of the chemical forms of many nutrients and their interactions during processing is far from complete, but it is known that the nutritional quality of a food is impacted by the balance of nutrients present. Arguments have been made that nutrient quality may be different for traditional and substitute products and that relative amounts of nutrients may determine whether the substitute is nutritionally inferior (6). The converse may also be true, because substitutes provide the manufacturer with an opportunity to improve the nutrient balance.

FUTURE DIRECTIONS

Imitation and substitute fluid and evaporated milks are not important as retail products in the United States. However, imitation condensed and shelf-stable ultrahigh-temperature processed milks and milk powders are important in the Far East and in developing countries where milk production is not adequate to meet the nutritional needs of the population. In terms of market share, margarines, buffer blends, and spreads represent the most important imitation products worldwide (5); it is expected that their importance will increase in the future. The development of fat substitutes (17) and the impact of their incorporation into traditional full fat dairy foods in place of milk fat remains to be determined. As medical knowledge expands, it seems certain that some consumers will continue to prefer substitute products that meet specific criteria for protein, carbohydrate, and lipid while providing traditional levels of essential nutrients.

BIBLIOGRAPHY

1. "Imitation and Substitute Dairy Products," *Dairy Council Digest* 54(1), 1-6 (1983).
2. U.S. Food and Drug Administration, "Filled Milk Products. Proposed Common or Usual Name," *Federal Register* 38, 20748 (Aug. 2, 1973).
3. *The Present and Future Importance of Imitation Dairy Products*, Bulletin No. 239, International Dairy Federation, Brussels, Belgium, 1989.
4. J. M. Saavedna and J. A. Perman, "Current Concepts in Lactose Malabsorption and Intolerance," *Annual Review of Nutrition* 9, 475-502 (1989).
5. *Consumption Statistics for Milk and Milk Products*, Bulletin No. 246, International Dairy Federation, Brussels, Belgium, 1990.
6. J. E. Vanderveen, "Nutritional Equivalency from a Regulatory Perspective," *Food Technology* 41(2), 131-132, 140 (1987).
7. U.S. Food and Drug Administration, "Imitation Foods": Application of the Term "Imitation." Final Rule," *Federal Register* 38, 20702 (Aug. 2, 1973).
8. Department of Health and Human Services, Food and Drug Administration, "Identity of Labelling of Food in Packaged Form," *Code of Federal Regulations*, Title 21, Chapter 1, Part 101, Food Labelling, Section 101.3, Revised Apr. 1, 1982.
9. C. R. Southward, "Uses of Caseins and Caseinates," in P. F. Fox ed., *Developments in Dairy Chemistry*, Vol. 4, Elsevier Applied Science Publishers, Ltd., Barking UK, 1990, Chap. 5.
10. C. R. Southward and N. J. Walker, "Casein, Caseinates, and Milk Protein Coprecipitates," in I. A. Wolff, ed., *CRC Handbook of Processing and Utilization in Agriculture. Volume I. Animal Products*, CRC Press, Inc., Boca Raton, Fla., 1982.
11. D. T. Rusch, "Vegetable Fat Based Dairy Substitutes," *Food Technology* 25, 486-490 (1971).
12. J. N. De Wit, "The Use of Whey Protein Products," Ref. 9, Chap. 8.
13. U.S. Pat. 4,309,417 (Jan. 5, 1982), L. C. Staples (to Stauffer Chemical Co.).
14. *Monograph on Recombination of Milk and Milk Products*, Bulletin No. 116, International Dairy Federation, Brussels, Belgium, 1979.
15. V. H. Holsinger, "Underutilized Proteins for Beverages," in D. A. Ledward, A. J. Taylor, and R. A. Lawrie, eds., *Upgrading Waste for Feeds and Food*, Butterworth & Co., Kent, UK, 1983.
16. J. A. Maga and O. O. Fajolu, "Carbohydrate Composition of Aseptically Packaged Soy-Based Drinks," *Lebensm. - Wiss. u. - Technol.* 20, 162-164 (1987).
17. N. S. Singer, "Simplex: All Natural Fat Substitute and the Dairy Industry," *Proceedings of the Dairy Products Technical Conference*, Chicago, Ill. Apr. 25-26, 1990.

V. H. HOLSINGER
P. W. SMITH
USDA, Eastern Regional
Research Center
Wyndmoor, Pennsylvania

MINERALS

Mineral nutrients are involved in the most fundamental processes of life. The oxygen that humans breathe is utilized with the aid of two metal complexes, ie, iron-containing hemoglobin and zinc-containing carbonic anhydrase. With the evolution of life from a reducing to an oxidizing atmosphere, mechanisms involving enzymes were developed by organisms in order to protect the cells from high levels of oxygen. One such class of protective enzymes is the superoxide dismutases that contain metals, eg, manganese, copper, zinc, and iron.

The human skeleton is composed of calcium and phosphorus and traces of other ions, eg, magnesium and sodium embedded in an organic matrix. The regulation of body-fluid volume and acid-base balance requires sodium, potassium, and chloride. Neuromuscular excitability and blood coagulation occurs in the presence of calcium. Metabolic energy, cellular homeostasis, and most enzyme activities are dependent on phosphorus. The electron-transport chain requires copper and iron. Several vitamins contain sulfur and one contains cobalt. Hormones contain iodine, sulfur, and zinc. Each cell contains complex sets of enzymes, many of which require metal ions, either as part of the basic structure or as activators.

As with other biological substances, a state of dynamic